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Applicant	(71)	UNION INDUSTRIELLE BLANZY-QUEST
Actual Inventor	(72)	MARCEL MONTACIE
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The following statement is a full description of this invention, including the best method of performing it known to us :

11746/75-L F. D. Atkinson, Government Printer, Canberra

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This invention relates to a continuous boring or cutting machine.

According to Patent No. 467,029 there is described a rotary tool head for a continuous boring or cutting machine, comprising a carrier arranged to be rotatably mounted on the machine, one or more tool holders mounted on the carrier, each having a plane of symmetry containing the axis of rotation of the carrier and being mounted for movement in that plane, and means on the carrier for moving the tool holders in their respective planes, so that, in use, the or each tool holder moves to and fro in a direction so as to cut a kerf eccentric of said axis of rotation, and when there is more than one tool holder, eccentric to one another.

According to the invention there is provided a continuous boring or cutting machine having at a forward end thereof a rotary tool head as described above, rotatably mounted on the machine and wherein there is further provided means operable to exert a forward thrust on the rotary tool head in such manner that, in use, the thrust exerting means is operative for a predetermined period of time after each change of direction of the tool holders during oscillation thereof, said predetermined period being less than the time interval between successive such changes of direction.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 shows a rotary tool head at a forward

end of one form of continuous boring or cutting machine in accordance with the invention,

Figure 2 shows a hydraulic control circuit for causing a tool holder of the rotary tool head to oscillate, and

Figure 3 shows a hydraulic system which is operative to apply periodically a forward thrust to the rotary tool head.

In Figure 1, a rotary tool head 1, rotated in the direction shown by an arrow 2 by a shaft 3 on which the head is fixed, is fitted with tools 4 in the form of cutter wheels rotating on respective shafts 5 in turn mounted on respective tool holders 6. The tool holders 6 are arranged to be driven in oscillating fashion on shafts 7 mounted on supports 8 of a carrier. The carrier, together with the tool holders, constitutes the rotary tool head 1.

Double-acting piston cylinder units 9 having cylinders with trunions 10 are mounted by the trunnions 10 in the supports 8 to drive the tool holders 6 in the required oscillating manner, a shaft 12 rotating in each of the tool holders 6 and crossed by the end of the piston rod 11 of the associated unit 9 ensuring the required driving connection between the unit 9 and its tool holder 6.

A hydraulic control assembly 13, comprising a number of control circuits for respectively controlling operation of the units 9, is mounted on the body of the continuous boring or cutting machine. The units 9 are connected to the hydraulic control assembly 13 through a rotating connection 14 having a fixed part 15 which is connected by fixed tubes 16 to the assembly 13 and a rotating part 17 which receives tubes 18 mounted on the head 1 and connected to the cylinders of the units 9, each of the tubes 18 being connected to a corresponding tube of the tubes 16 to provide the necessary hydraulic connections of the individual piston cylinder units 9.

The axes of the shafts 7 on which the tool holders 6 oscillate are perpendicular in space to the axis

of rotation of the shaft 3 bearing the rotary tool head 1 and are situated, in space, at equal distances from the latter. Likewise the shafts 10 and 12 are perpendicular to the shaft 3 and the tool holders each have a plane of symmetry which passes through the axis of rotation of the shaft 3, irrespective of the position of the tool holder as permitted by its oscillatory movement, and contains the rotation axis of the shaft 5 on which the tool 4 turns freely.

A tunnel 19 which has a toroidal working face 20 is cut away by four tools 4. The period of oscillation of the tool holders in relation to the speed of rotation of the head during normal operation of the machine is such that, so long as each tool holder continues to move in the same direction throughout a half cycle of oscillation, cuts of substantially spiral shape in the respective sections 20a, 20b, 20c and 20d are formed by the four tools. When there is no oscillation of the tool holders, the tools each form a circular cut as is known in machines where the tools are fixedly mounted directly on the front of a rotary head.

The tool at the top of Figure 1 oscillates so as to form a cut over the section 20a and the tool at the bottom oscillates so as to form a cut over the section 20b. Of the positions which each tool is able to occupy over the respective section, it is shown in Figure 1 as occupying the position furthest away from the axis of the shaft 3. Each tool occupies this position at the moment when its oscillating direction is about to change from outwardly to inwardly.

In Figure 2, a cylinder of a unit 9 is shown connected with its hydraulic control circuit, whose hydraulic oil, arriving through the tubes 16, passes in the tubes 18 after having crossed the rotating connection 14. It is the rod 11 of the piston 21 within the cylinder that ensures the oscillating movement of the corresponding tool holder 6 (not shown). Each cylinder is connected up, by way of the tubes 16, to a double pump having two bodies 22 and 23 respectively whose cylinders may be brought into communication with chambers 24 and 25 respectively, these chambers being within the cylinder of the unit 9 and separated by the piston 21. These two chambers are of different effective cross-sectional areas owing to the rod 11 which moves in the chamber 24.

The drive for the double pump is by means of a shaft 26 which is to great advantage, driven in the direction of the arrow 27 by an independent electric motor, it being possible for one and the same electric motor to drive all the double pumps of the various tool holders. It is evident that the double pump could be arranged to be driven mechanically by the rotation of the rotary tool head.

Electrodistributors 28 having four channels, which distributors each have two operating conditions controlled by a winding 28a, are installed between the pump bodies 22, 23 and the chambers 24, 25 to control the oil flow direction in the hydraulic circuit. In one operating condition of each distributor 28 the hydraulic connections between the left-hand and right-hand channels are as indicated by the arrows 30 whereas in the other operating condition the hydraulic connections are as indicated by the arrows 37.

Thus, with reference to Figure 2 and in the first-mentioned operating condition, the rod 11 enters the cylinder of the unit 9, in the direction of the arrow 29, to move the corresponding tool away from the axis of rotation of the head, under the effect of the oil under pressure, supplied to the chamber 24 from the pump body 22, flowing through the distributor 28 in the direction of the arrow 30 and passing in the tube 16 in the direction of the arrow 31 to enter the chamber 24. At the same time oil is discharged from the chamber 25 to pass via the right-hand distributor in Figure 2 to the inlet side of the pump body 23 from where it is pumped back to an oil tank 32 which is subjected to a pressure of the order of one bar. The pump body 22 in turn takes its supply of oil from the tank 32 through a central tube 33 and a non-return valve 34, and also through a tube 35 and the distributor 28. Appropriate arrows show the oil flow direction. Other non-return valves and pressure limiters 36 complete the hydraulic circuit, the tubes 33a shown in dotted lines being used for the scavenging of leakage oil. When the distributors are in their other operating conditions, the piston 21 and rod 11 move to the left in Figure 2, the oil flow directions in the tubes 16 and 35 being reversed but operation of the circuit being similar to that when the distributors are in their first-mentioned operating conditions and also being readily apparent from Figure 2. Thus, such operation will not be further described.

By regulating the pump discharge, the theoretical time of an outgoing or return stroke of the piston 21 of the unit 9 is regulated at a value T. By means of a time-

switch device (not shown), the simultaneous reversing of the distributors 28 of the tool carrier assembly 6 is effected at intervals of time To = T + _t_, _t_ being a very short time in relation to T and being, more specifically, of the order of one second which enables synchronisation of the oscillating of all the tool holders to be ensured, the rods 11 being blocked during the time _t_ by means of the pistons 21 abutting in each case against one of two rings 38 respectively positioned at the ends of the cylinder of the associated unit 9, whereas the pumps discharge at that instant through their pressure limiters 36.

The time-switch device controls the operation of the distributors 28 by means of a cohtact switch equipped with one contact for each tool holder 6 to be controlled, the contact switch being of the open or closed type. Each contact switch controls respectively the de-energising and supplying of the windings 28_a_ of the distributors 28 assigned to the hydraulic control circuit of a different one of the tool holders so as to select the oscillating direction of the tool holders, the ones whose cuts cover the two innermost sections 20_c_, 20_d_ moving outwardly in the direction of arrows 39_c_, 39_d_ when the ones whose cuts cover the two outermost sections 20_a_, 20_b_ are moving inwardly in the direction of the arrows 30_a_, 39_b_ and _vice versa_ for the other direction of tool holder movement (see Figure 1). Actually, for practical considerations, it is to be noted that the oscillation of the tool holders bearing the tools which form cuts over the sections 20_a_, 20_b_ should be synchronised in such manner that the two tool holders concerned move inwardly together and outwardly together.

Variations in the described hydraulic control circuit are possible. Thus, double pumps with axial pistons can be used, reversing of the oil flow being effected by reversing the plate of this pump. In the case where pistons 21 equipped with a double rod are provided (as is possible), the effective cross-sectional areas of the chambers 24 and 25 of the unit 9 are then the same and a single pump with axial pistions can be used. The required reversing of the hydraulic flow for causing the tool holders to oscillate can alternatively be effected by mechanical reversing of the direction of rotation of the single or double pump, either through a mechanical invertor or directly by reversing the direction of rotation of the drive motor of the pump.

The speed of rotation of the rotary head is determined during manufacture and is in practice considered as being constant, taking into account the inertia of the rotary head and drive therefor by a high power motor.

The average oscillating frequency of the tool holders is also determined during manufacture and in relation to the angular rotating speed of the rotary tool head so as to cause (as mentioned above) each tool to form a cut having a substantially spiral shape of given medium pitch on the working fade while the tool is moving either outwardly or inwardly. To take into account the various working parameters, more particularly the hardness of the rocks in the ground to be bored, the pitch of the substantially sprial cut can be adapted to the work required by modifying the discharge of the pumps in the hydraulic circuits associated with the units 9, but the maintaining of the cutting pitch which

in turn depends on the ratio between the rotating speed of the rotary tool head and the oscillation frequency of the tool holders is not critical. In fact, since the speed of head rotation is practically constant while the oscillation frequency of the tool holders is adjustable, strict synchronising of these two movements is not obtained and it will generally be possible to employ independent drive means for rotating the head and oscillating the tool holders.

Referring to Figure 3, an hydrualic pump 40 having an adjustable discharge of Q litres per second, is driven in the direction of the arrow 41 by an electric drive motor 42 and discharges into a hydraulic accumulator 43 whose inflation pressure is greater than that necessary for periodically advancing the rotary tool head into the working face of the tunnel during boring or cutting. A single hydraulic distributor 45 electrically controlled by a winding 45<u>a</u> and normally closed is mounted between the accumulator 43 and the cylinders of thrust jacks 44, these cylinders being mounted between the structure of the machine bearing the rotary head 1 and parts of the machine which are fixed relative to the base of the tunnel during each advancement of the rotary head into the working face.

At each change in direction of oscillation, of the tool holders, the time switch device for controlling the required change of direction by means of the four-channel electro-distributors 28 also controls, by means of time delay relays, the opening of the single distributor 45 during a time which is of course, less than the time of a half oscillation of the tool holders and which is adjust-

able between two and four seconds, enabling all of the oil accumulated in the accumulator 43 during the closed condition of the distributor 45 to pass into the cylinders of the thrust jacks 44, and thus ensuring the progressive advancement of the rotary cutting head in stages.

Thus, at each change of oscillation direction of the tool holders, the machine advances a certain distance which is dependent simultaneously on the magnitude of the time T in which the tool holders undergo a half-oscillation and also on the selected value of the adjustable discharge Q of the pump 40.

In the case of a cutting machine, the forward thrust on the rotary head may be produced by means of tracks on which the machine is mounted, these latter being driven by a hydraulic motor, and the advancement in stages of the rotary head is then obtained by supplying the hydraulic motor with oil from the accumulator 43 during the period of discharge of the latter.

The hydraulic control system shown in Figure 3 is equipped with a general oil tank 46 at which the various hydraulic branches of the control system, equipped, moreover, with pressure limiters 47 and 48, non-return valves 49 and 50 and stop cocks 51 used for isolating the accumulator 43, end.

With the machine described, after each forward thrust on the head and before the next reversal of tool holder direction, a substantially constant torque is required to effect oscillation of the tool holders.

The claims defining the invention are as follows:-

1. A continuous boring or cutting machine having at a forward end thereof a rotary tool head comprising a carrier rotatably mounted on the machine and one or more tool holders mounted on the carrier, each having a plane of symmetry containing the axis of rotation of the carrier and being mounted for movement in that plane, and means for moving the or each tool holder in their respective planes so that, in use, the or each tool holder moves to and fro in a direction so as to cut a kerf eccentric of said axis of rotation, and when there is more than one tool holder, eccentric to one another, the machine further including means operable to exert a forward thrust on the rotary tool head in such a manner that, in use, the thrust exerting means is operative for a predetermined period of time after each change of direction of the tool holders during oscillation thereof, said predetermined period being less than the time interval between successive such changes of direction.

2. A machine according to claim 1, wherein the thrust exerting means comprises hydraulic means.

3. A machine according to claim 2, wherein said hydraulic means incorporates hydraulic thrust jacks for exerting a forward thrust on the rotary tool head.

4. A machine according to claim 3, wherein said hydraulic means further includes a hydraulic accumulator arranged in use, to accumulate fluid when said hydraulic means is inoperative and to discharge accumulated fluid into the cylinders of the thrust jacks when said hydraulic

means is operative.

5. A machine according to claim 4, wherein said accumulator is provided with an electrically operated hydraulic distributor arranged to control discharge of said accumulator.

6. A machine according to any preceding claim, wherein the means for moving the tool holders

incorporates double-acting piston cylinder units mounted on the head and arranged to oscillate respective ones of the tool holders, and hydraulic control circuits mounted on the machine and each hydraulically connected, by means of a common rotating connection, to a different said piston cylinder unit, each control circuit having a hydraulic double pump for supplying, in use, oil to the associated piston cylinder unit and hydraulic electrodistributor means energisable to control, in use, the supply of oil to said unit.

7. A machine according to claim 6, wherein the means for moving ~~oscillating~~ the tool holders further incorporates a contact switch having contacts, each arranged to energise and de-energise a different said electrodistributor means, and a time switch device arranged to control periodically operation of said contacts.

8. A machine according to claim 7, when appended to claim 5, wherein the electrically operated hydraulic distributor is provided with time-delay relays and the time switch device is arranged to supply the time delay relays, to energise said hydraulic distributor, simultaneously with controlling operation of said contacts.

9. A continuous boring or cutting machine substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

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PHILLIPS ORMONDE AND FITZPATRICK
Attorneys for :
UNION INDUSTRIELLE BLANZY-OUEST

MT

David B Fitzpatrick

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FIG. 2

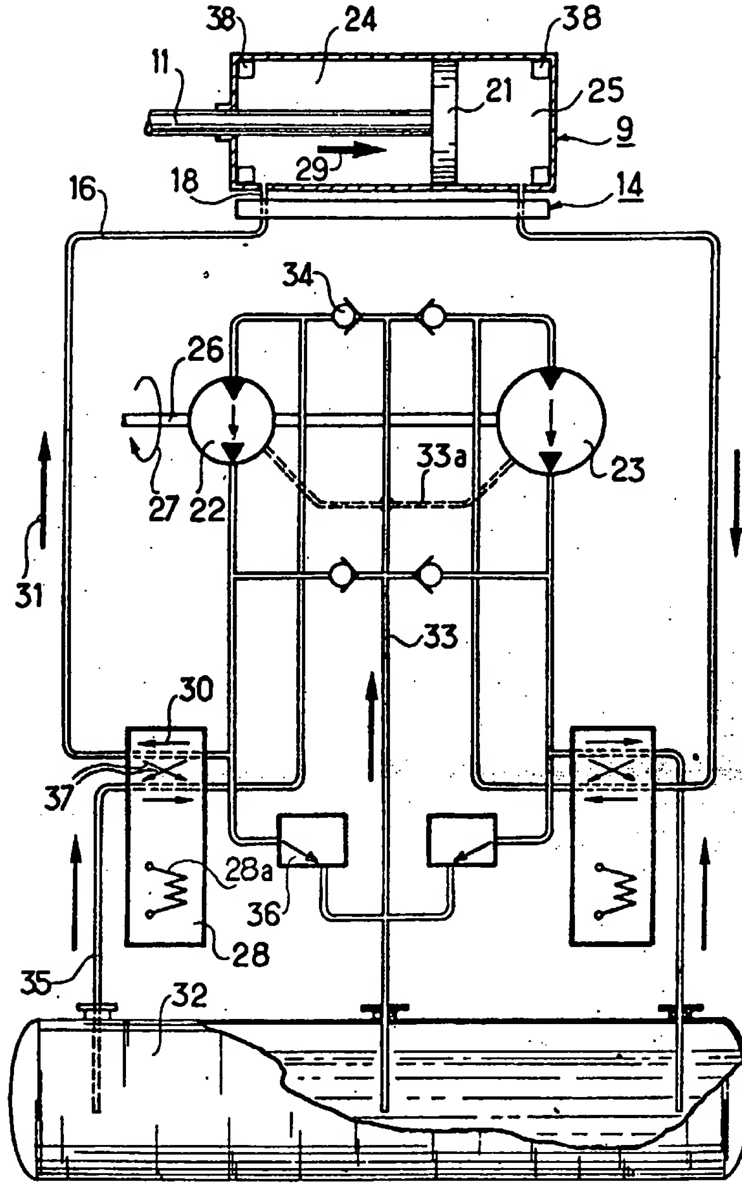

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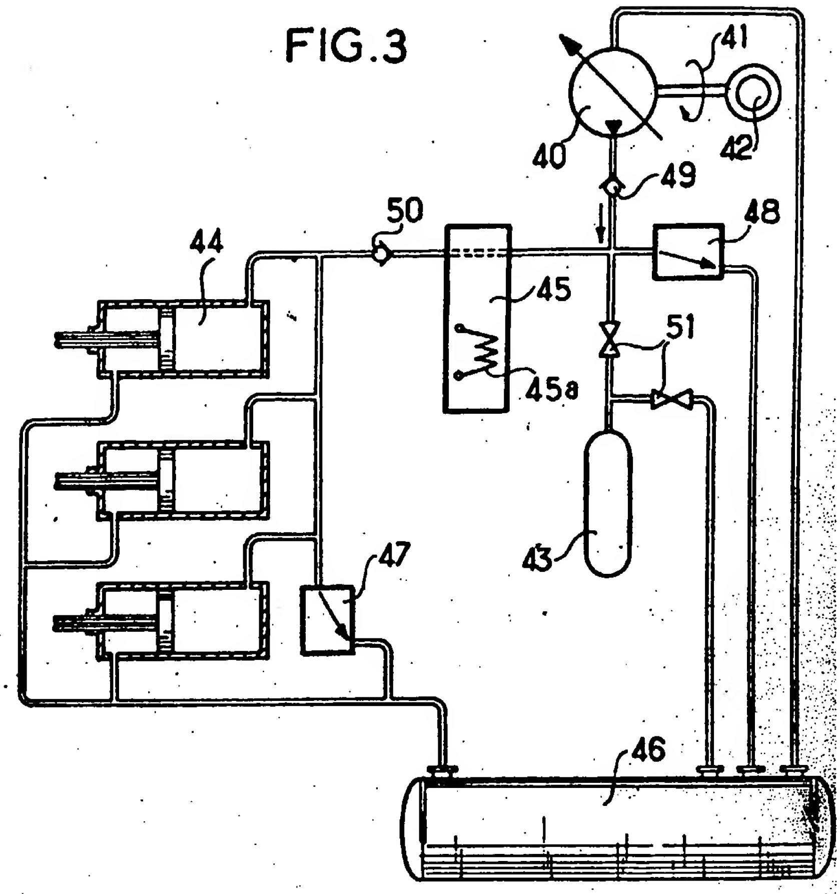
FIG.3



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